Chemical & Engineering NEWS
November 30, 1981

Mass spectrometers in tandem yield wealth of new information
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BASIC PETROCHEMICALS

Big problems brew for 1982

A Key Chemicals Review Page 11

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Chemical & Engineering NEWS

Cover: Propylene fractionation towers of Hercules' joint venture with Enterprise Petrochemicals Co. in Mont Belview, Tex.

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Basic petrochemicals still in trouble

With output falling in current business recession, basic olefins and aromatics face another year of low prices, profits, plant use

U.S. producers of basic petrochemicals are facing some of the most difficult times since the petrochemical industry first started in the early 1900's. The next few months probably will mark the low point of the current business trough. But after that, petrochemicals will take at least another year to regain their late-1970's volume.

That means three years of no growth from 1980 through 1982. Since plant capacity has moved up substantially, and petrochemicals' main cost load, in raw materials, has gotten much heavier, this bedrock product group is in very poor financial shape. For example, profits in leading oil companies' petrochemical operations in the third quarter were even worse than in last year's recession.

Unfortunately, some brand-new problems loom for petrochemicals over the next few years. One way or another, government-repressed prices for the olefins' most important raw material, natural gas, will be lifted. This will hand petrochemicals another huge increase in costs. If it happens too soon, petrochemical producers, caught in a surplus market, will have a rough selling job to talk customers into accepting higher prices. Customers may say no or turn to imports.

Imports, already increasing, could become a flood by the mid-1980's. Although much of these imports would come in the form of derivatives of the basic petrochemicals, the effect on U.S. petrochemicals would be the same—lost markets.

Imports could gain handsomely because the main wave of new petrochemicals production in the world will come from giant, efficient new plants built close to enormous foreign oil and natural gas fields. In other words, these plants will be making petrochemicals, especially olefins, by the simplest processes from the cheapest raw materials.

The only buffer for U.S. petrochemicals would be the foreign plants' relatively high capital cost and the transportation cost to markets. But these costs pale beside the dominant raw materials costs, which are naturally lower in western Canada, Mexico, and the Middle East.

The gush of new petrochemicals production in the world would be fine if world economies were bursting with growth. There would be room for everyone. But world economies at the moment are quite sick, and growth is at a standstill.

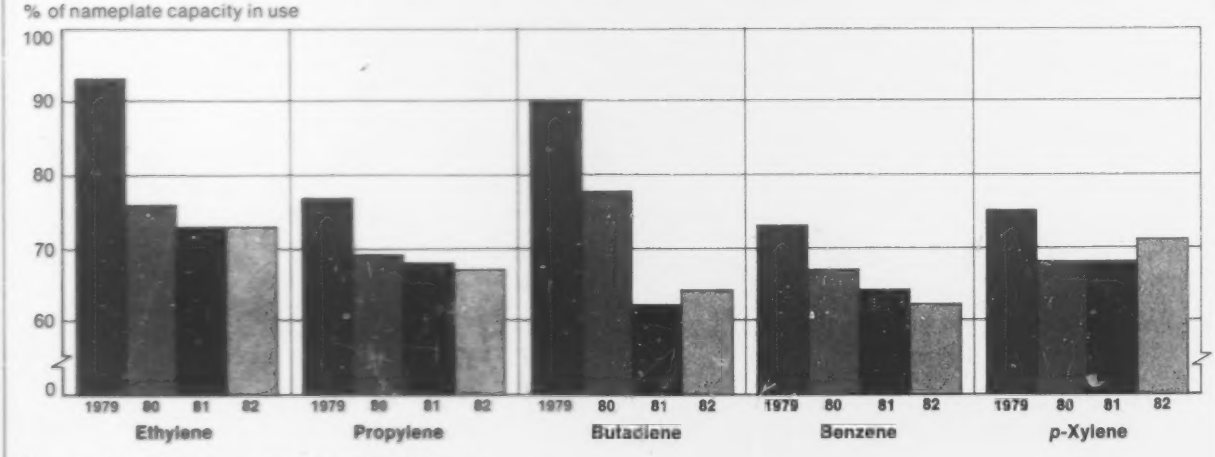
The drastic decline in market growth in the U.S. has undercut all the optimistic forecasts of the past few years for petrochemicals in the 1980's. The production outlook for the five major petrochemicals covered in the following pages—ethylene, propylene, butadiene, benzene, and *p*-xylene—is the same volume, 62 billion lb, in 1982 as in 1979.

But plant capacity for these five products jumped 21% from early 1979 to early 1982, to 93 billion lb per year. The yearly increases were 8% in both 1979 and 1980 and 4% this year. Meanwhile, production fell 9% in 1980, is rising 4% this year, and may rise 3% in 1982.

Growth in value for the five chemicals also has throttled down. The average weighted price for this group rose 29% in 1980 to 22 cents per lb from 17 cents in 1979. But the average price moved up only 9% in 1981 to 24 cents. Thus, total production value of these chemicals moved up 22% in 1980 to $13.2 billion but then rose just 13% in 1981 to $14.9 billion.

Bruce Greek, Houston, and William Fallwell, Washington

Petrochemical plants still will run at very low levels in 1982



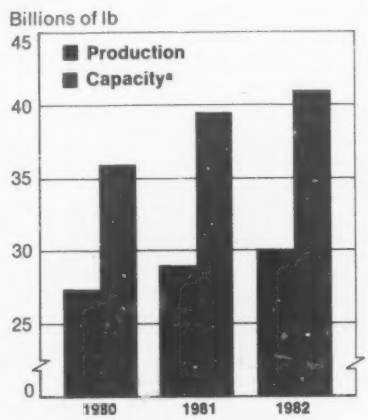
Sources: Industry, C&EN estimates, International Trade Commission

$CH_2=CH_2$

Ethylene

- ***Demand in slump***
- ***Capacity going up***
- ***Prices way down***

PRODUCTION/CAPACITY



a First quarter.

HOW MADE

Thermal (steam) and catalytic cracking of hydrocarbons ranging from natural gas-derived ethane to oil-derived gas oil (fuel oil)

MAJOR DERIVATIVES

Polyethylene 45%, ethylene oxide 15%, vinyl chloride 10%

MAJOR END USES

Fabricated plastics 65%, antifreeze 10%, fibers 5%, solvents 5%

FOREIGN TRADE

Negligible

PRICES

List price 25.5 cents a lb

COMMERCIAL VALUE

$7.0 billion for 1981 production

In the ethylene business, an irresistible force met an immovable object. Something had to give.

It wasn't the U.S. public, whose forceful letup in spending amid towering interest rates led to a new recession. It had to be ethylene producers, who have chopped prices to stay alive or given up and shut down plants.

These producers face an ever more difficult question: How low will prices go for the leading organic chemical and the largest-volume olefin? To many, the current list price of 25.5 cents per lb is below what they had thought was rock bottom. But to their dismay, further discounts of 8% are common. Larger discounts of 10% and more are widely rumored.

The basic problem is a classic case of too much plant capacity. To boot, much of this excess is the wrong kind, built to run on what looked like the only kind of feedstock available, high-priced gas oils and naphthas instead of traditional ethane and propane.

It's not hard to guess which kinds of plants have stopped running. More shutdowns may be the only solution for now, and the naphtha and gas oil crackers will be the ones to go.

Ethylene plants can be divided into these two broad types. About half or a little more, mostly older with lower capital investment, are fed very light liquids from natural gas, mainly ethane and propane. The rest run on heavier, oil-derived hydrocarbons of six or more carbon atoms—naphtha (like gasoline) and gas oil (like fuel oil).

This distinction has become a bit tricky. Due to modifications and experimenting, the boundary has blurred. Operators of ethylene plants designed for naphthas and gas oils are reducing their feedstock costs by substituting any light hydrocarbons they can get their hands on.

Currently, light liquids-based ethylene plants have a significant cost advantage over other ethylene plants. Ethane in particular has dropped in price as plant capacity has risen to take it out of natural gas. The exact cost advantage is difficult, if not impossible, to pin down.

But the advantage is very real. It has brought about shutdowns of varying amounts of capacity, nearly all steam crackers designed to use heavy hydrocarbons. The amount of ethylene capacity closed varies depending on factors such as feedstock availability, inventories of ethylene and its derivatives, and the sales outlook for these products. At mid-November, estimates of idled capacity ranged from 4 billion to 7 billion lb per year.

If November nameplate capacity is 41 billion lb per year, and shut-down capacity is about 5 billion lb, the remaining capacity would be running at an average rate of 75% or 27 billion lb per year. Industry analysts find telling evidence for such a low use rate in producers' bulging inventories. Inventories got this big because plants ran high last spring on optimistic sales forecasts for the second half of 1981.

The present slack is expected to hold ethylene production this year to about 29 billion lb, up 6% from 27.4 billion lb in 1980. However, industry projections range all the way from 28 billion or less to nearly 31 billion lb.

Part of the reason for this comparatively broad range comes from analysts' suspicion that some ethylene producers, with well over 1 billion lb of nameplate capacity, are not reporting monthly production. Unreported production, plus errors in reporting, could make the final 1981 production figure quite different from preliminary estimates.

Next year, the outlook for ethylene production depends entirely on the economy. Assuming a much improved second half, plus efforts to find new uses for ethylene derivatives, production of ethylene in 1982 could top 30 billion lb, but not by much. The current swollen inventory, equivalent to nearly two months' production, will have to be worked down during 1982's first half.

Behind the surge in inventories is an unexpectedly large decline in demand for ethylene derivatives, particularly polyvinyl chloride and polystyrene. The conventional polyethylenes have had their inventory problems too. Demand is shifting to the new-generation linear low-density polyethylenes.

The major ethylene derivatives all have lower long-term growth forecasts than in the past. Demand for derivatives is expected to pick up a little in 1982, but the ethylene business may never again be so lively as it once was.

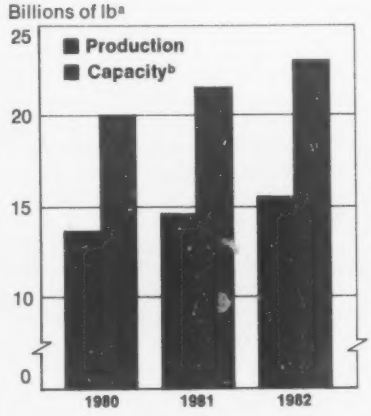
Key Chemicals

$CH_2=CH-CH_3$

Propylene

- ***Demand up a bit***
- ***Capacity rising***
- ***Prices holding***

PRODUCTION/CAPACITY



a Chemical and polymer grades. b First quarter.

HOW MADE

Recovered from cracked gas streams of olefins plants and oil refineries

MAJOR DERIVATIVES

Polypropylene 25%, acrylonitrile 15%, cumene 10%, isopropanol 10%, propylene oxide 10%

MAJOR END USES

Fabricated plastics 50%, fibers 15%

FOREIGN TRADE

Exports—negligible, imports—small, about 500 million lb in 1981

PRICES

Chemical grade 22 cents per lb; polymer grade 24 cents per lb; discounts small

COMMERCIAL VALUE

$3.25 billion for 1981 production

Comfort is very relative, and very scarce, in petrochemicals these days. The product closest to it in the current economic storm is propylene. Propylene's secret, oddly, is its complete lack of production independence. Although this may not sound too healthy, for the moment it means propylene is much better off than ethylene.

Propylene is in fairly good financial shape because its supply is held down by depressed production of coproduct ethylene, and its markets are stronger than ethylene's. The upshot is that propylene is not in a glut even in the current recession.

U.S. producers of propylene also find themselves in an unusual price position. Prices for much of polymer-grade (higher purity) propylene are almost as high as for ethylene, which usually rates several cents a pound more.

However, propylene output has to keep pace with ethylene. Forecasts for propylene production in 1981 call for an increase of about 7% to 14.7 billion lb from 1980. These estimates are for combined chemical and polymer grades. A further increase of 5% to about 15.5 billion lb is expected in the industry in 1982.

Demand for chemical- and polymer-grade propylene continues to be good compared to demand for other major organic chemicals. Since propylene supply is not much more than adequate, the market hasn't forced much discounting of propylene's price. Inventory building also has been relatively small compared to the bloated condition of ethylene. The snug fit of demand and supply for propylene could continue through most of 1982.

Fairly good demand is the rule through much of propylene's diverse line of derivatives. Derivatives exports appear to be holding up well this year, in contrast to declines in many other organics. U.S. demand for some derivatives has held up well, although it has fallen off for leading polypropylene in recent weeks. Until recently, technological innovations for polypropylene have kept demand at an even pace, if not up a bit.

Although demand has been very important in keeping up propylene's prices, supply factors are becoming even more important. If ethylene demand doesn't improve, some industry sources see a growing tightness in propylene supplies next year.

Propylene generally is the coproduct, not the primary product, in both its main sources—steam-cracking ethylene plants and oil refineries' catalytic crackers. A bit over half of both chemical- and polymer-grade propylene comes from steam cracking operations. For practical purposes, all of the propylene made in steam crackers becomes a chemical product. This contrasts with refinery propylene, of which part is never recovered and much goes to alkylation and other fuel uses outside chemicals.

Currently, both sources of propylene are operating well below practical capacity. The result is below-normal propylene supply. In the case of steam crackers, it isn't just low ethylene demand that has crimped propylene. Because the cost of raw material gas oil and naphtha is well above costs of alternative ethane and propane, operators of steam crackers have shifted to the lighter hydrocarbons as much as possible. Output of propylene from ethane and propane is meager compared to output from the heavier feedstocks.

Oil refineries have a large amount of propylene theoretically available from catalytic cracking operations. However, the cost of purifying this propylene, which often occurs in low concentrations, often can't be justified, especially to make the higher quality polymer-grade propylene. Hence, refinery capacity for each purification is well below the volume of crude propylene available.

Of course, for a price almost anything is possible. So things could change. For example, if propylene, especially polymer grade, becomes very tight, crude propylene streams from refineries could find their way to purification facilities of steam cracker units. Since many companies have both kinds of facilities close to each other, they easily could handle more propylene at not too much additional cost.

Hence, if demand for propylene derivatives continues relatively strong, then more refinery propylene will move into chemical and polymer uses during 1982. Producers will have to recover the additional costs involved. So prices are expected to firm even more in 1982.

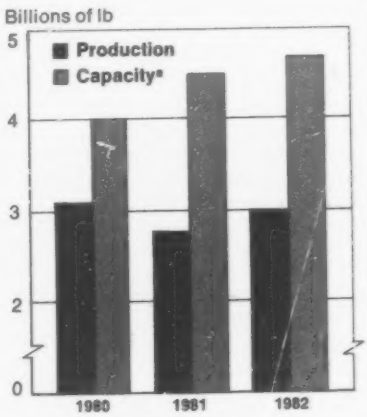
Key Chemicals

$CH_2=CH-CH=CH_2$

Butadiene

- ***Demand off***
- ***Capacity up***
- ***Prices holding***

PRODUCTION/CAPACITY



a First quarter; includes all sources.

HOW MADE

Recovered from steam cracker product streams; dehydrogenation of butylenes from oil refineries

MAJOR DERIVATIVES (U.S.)

Styrene-butadiene rubber 50%, polybutadiene rubber 20%

MAJOR END USES (U.S.)

Rubber products 80%, fibers 10%

FOREIGN TRADE

Exports—about 125 million lb, imports—off to about 350 million lb

PRICES

List price 42 cents a lb less 2 cents temporary cut

COMMERCIAL VALUE

$1.1 billion for 1981 production

Things are rarely what they seem for butadiene, the only big-volume commercial diene. Like propylene, it has two distinctly different sources in the U.S. But unlike propylene, butadiene also has a large, quirk-ridden foreign trade and a truly worldwide market. Add to this its chemical instability and single-market dependence on rubber. It's a business with plenty of suspense.

At the moment, this odd mix of forces gives U.S. butadiene much more firmness than its woebegone market suggests. One key is a big drop in imports because of a shift in world markets.

U.S. producers of butadiene have cut production this year but not so much as demand has fallen. The result will be output of about 2.8 billion lb, down 10% from 1980.

Despite the production drop, butadiene isn't faring that badly. Imports are expected down 40% or more to about 350 million lb this year. And production at both U.S. sources is actually close to its upper limit. Prices are considered relatively strong.

Behind butadiene's low volume is the wretched auto market. Rubber and tire production is easing further this fall as auto production drops and replacement tire sales dip. Tires and fabricated rubber products, a large part of which goes into autos, account for 80% of butadiene demand in the U.S.

Separately, coproduct butadiene output at olefins plants is falling because of these plants' low operating rates and feedstock switching. Much olefins capacity is shut down now. Production still running operates well below capacity, and the emphasis on cheaper light hydrocarbon feedstocks reduces proportionate output of butadiene.

The result is that the decline in U.S. butadiene production has all come out of these olefins plants. This situation will continue well into 1982, possibly throughout the year, unless a significant recovery from the current recession gets under way.

Butadiene's other U.S. source, independent dehydrogenation plants, is going almost full blast. These plants generally are operating at about their economic maximum, between 85 and 90% of nameplate capacity.

Most of the dehydrogenation plants and many of the multiproduct olefins plants either are owned by a producer of butadiene polymer or are closely associated with such producers. Hence, a lot of butadiene is funneled straight into polymerization by the same producer. Any additional butadiene then is purchased from outside olefins producers who may have no captive use for coproduct butadiene.

The remaining source of U.S. butadiene is imports, traditionally coming almost entirely from Western Europe. Europe's ethylene capacity long has been based totally on heavy feedstocks, which results in relatively large quantities of coproduct butadiene compared to the U.S. Surplus butadiene is generally the rule.

Around the globe, Japan's ethylene production, too, has been naphtha-based, but Japan's internal needs for butadiene usually have been so large that exports have been small. However, since Japan's ethylene plants now are running at reduced levels and demand for rubber there is still reasonably strong, Japan needs butadiene from Europe. So European butadiene producers have relatively less material to send to the U.S. That's just as well, under the circumstances.

The net result is that butadiene is one of the few major U.S. petrochemicals with reasonably strong prices. Depending on recessionary developments in the first and second quarters of 1982, prospects for butadiene prices are for no change or a slight firming. This is especially true if some additional olefins capacity is shut down. Of course, if U.S. auto production sags even more in the first half of 1982, butadiene demand will drop too, which could possibly weaken prices.

In 1981, actual demand, as opposed to production, for butadiene will total close to 3.1 billion lb. The major rubber uses, some three fourths of the total, will bear the brunt of the 500 million lb decline from 1980.

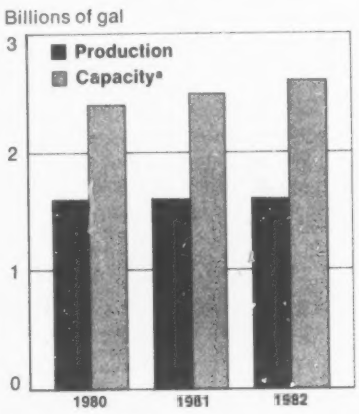
Customers' rebuilding inventories of finished rubber and downstream rubber products could help butadiene in 1982, but butadiene's U.S. capacity limitations may hold this down. At least, butadiene prices would avoid the sickly prospects that are confronting many other organic chemicals.

Key Chemicals

Benzene

- ***Demand flat***
- ***Capacity up a bit***
- ***Prices driven down***

PRODUCTION/CAPACITY



a First quarter; includes all sources.

HOW MADE

Separated from aromatics streams from oil refineries, steam-cracking olefins plants, coking of coal. Also via dealkylation of toluene

MAJOR DERIVATIVES (U.S.)

Ethylbenzene 50%, cumene 20%, cyclohexane 15%, aniline 5%

MAJOR END USES (U.S.)

Polystyrene 25%, phenolics 20%

FOREIGN TRADE

Exports—small, imports—rising to more than 100 million gal in 1981

PRICES

List price $1.55 per gal

COMMERCIAL VALUE

$2.4 billion for 1981 production

Like ethylene, benzene takes recessions broadside. It seems to have no protection from them. In theory, the leading aromatic is buffered slightly by some of the same supply constraints saving propylene and butadiene from gluts. In practice, however, benzene is too freely available, and its markets too weak, to ward off a crunch.

A crunch is exactly what has hit benzene over the past half-year. The best indicator is a 15% contract price drop since January. Alone among the top five petrochemicals, benzene will be worth less in 1981 than in 1980.

Benzene producers now are pulling through a slow fourth quarter. They fear that things wil not brighten in early 1982 either. All hopes of real improvement are delayed to 1983 at best.

Since the current quarter appears to be the slowest of the year, total benzene production in 1981 will do well to match that of 1980 at a bit less than 1.6 billion gal. Next year, because of an expected slow first half, production will again do well to reach 1.6 billion gal.

These estimates for 1981 and 1982 represent a consensus of industry sources. They differ from an official production total of 1.8 billion to 1.9 billion gal extrapolated from the latest 1981 data from the U.S. International Trade Commission.

The exact reason for the discrepancy is unknown. Some industry opinion is that the government figures are suspect. The reasoning goes that efforts of companies to reduce overhead costs have resulted in transfer of production reports from operating management to staff functions such as data analysis and government contact departments. Personnel in these departments are less familiar with operating procedures and hence are unable to detect inconsistencies in data. Poor or irrelevant data then go to ITC, leading to inaccurate official reports.

Plant capacity for benzene totals 2.6 billion gal a year and is rising slowly. There are four separate sources: catalytic reformate in oil refining, pyrolysis gasoline in olefins plants (significant if the feedstock is naphtha, gas oil, or a similar heavy hydrocarbon), dealkylation of toluene, and coal tar.

Each of these sources has special circumstances in its operation. As a result, production at a particular benzene plant can vary from all-out to nothing and sometimes not reflect the actual market pace.

At present, these special influences are very much at work. At refineries, the biggest source, weak gasoline demand is reducing pressure on aromatics production (for octane boosters) but not enough to block benzene for chemical use. Because of its sheer size, refinery benzene is the swing source. Benzene production for chemical use usually can move up or down with only a small impact on aromatics that go into gasoline.

Refinery benzene conditions largely determine how much extra benzene is produced by dealkylation of toluene. If benzene prices are weak, as at present, and raw material toluene not cheap enough, dealkylation units shut down. It doesn't take much time or money to close or reopen these units. So the dealkylation route is in and out of operation as the economic wind blows.

The third source of benzene, olefins plants, also is in a slump. Like coproduct propylene, coproduct benzene output is low because of plant shutdowns and substitution of light feedstocks for the heavies. Almost no benzene is produced when the feedstock is an ethane-propane mix. Only small amounts result from butane feedstock.

The final benzene source, coal tar, is small. It has been hurt by a decline in steel, which leads to lower demand for coal.

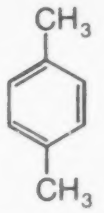
Overall, benzene production has been held down a bit in all of its sources. But markets have died down even more, and benzene is in clear surplus. Hence the deep price cuts.

Short-term prospects for improved demand for benzene by derivative makers are poor. Styrene, the major use of benzene through ethylbenzene intermediate, is expected to have little growth in demand in 1982 as in 1981. Styrene polymers, with styrene either alone or with other monomers, are headed for minor increases in 1982 or none at all.

Other benzene derivatives such as phenol and cyclohexane face equally bleak prospects because their main uses are in housing, an industry going steeply downhill.

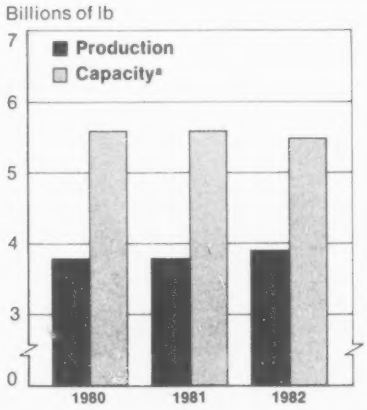
Key Chemicals

p-Xylene



- ***Demand flat***
- ***Capacity shaved***
- ***Prices level***

PRODUCTION/CAPACITY



a First quarter.

HOW MADE

Separated from mixed xylenes made in oil refineries or in steam-cracking olefins plants

MAJOR DERIVATIVES (U.S.)

Dimethyl terephthalate 55%, terephthalic acid 45%

MAJOR END USES (U.S.)

Polyester fiber, film, and fabricated items, mostly bottles, almost 100%

FOREIGN TRADE

Exports—800 million to 900 million lb, imports—may rise to 40 million lb

PRICE

List price 31 cents a lb

COMMERCIAL VALUE

$1.1 billion for 1981 production

The long-suffering *p*-xylene business finally has a glimmer of good news. Although the temptation is to record it quickly before it goes away, the product actually may have made some basic, lasting improvements.

In its own lesser way, *p*-xylene has had the same shakeout as has its leading market, polyester fiber. Two producers are effectively out of production, and both plant use and prices are up. At the same time, *p*-xylene's important exports have resisted the general export decline among organics.

All told, U.S. producers of *p*-xylene probably consider themselves among the less damaged in the organic chemical world. Demand for their product is flat at 3.8 billion lb in 1981, but part of the reason is promisingly high capacity use in polyester fiber. Overcapacity in *p*-xylene has been reduced as one company, Shell Chemical, has left the business and another, Hercor, has stopped production for lack of raw materials.

Reflecting higher crude oil prices, producers have been able to raise the list price of *p*-xylene 4 cents a lb over a year ago. Although not all of the product moves at list price, the increase is enough to push production value more than 20% higher than 1980. One caution: Since the cost of feedstock went up at least as much and processing costs almost as much, little of the price increase is likely coming down to producers' bottom line as increased profits.

Much of *p*-xylene's renewed strength comes from stable export demand, which should match 1980 at more than 800 million lb. This is nearly a quarter of production, very high for a petrochemical. Although it's true that an important part of these exports eventually comes back to the U.S. as finished textiles, thereby curbing U.S. sales of *p*-xylene, export demand still can make or break producers.

Plant capacity for *p*-xylene isn't so large as it was last year, or in fact so large as it seems on paper. Shell's capacity has been gone for part of 1981. In Puerto Rico, Hercor's has been up and down depending on the fortunes of its feedstock source, financially troubled Commonwealth Oil Refining Co. The plant is now down. These output cuts, plus long maintenance shutdowns during the year, have reduced operating capacity for 1981 on average to about 5 billion lb, 10% below nameplate capacity of 5.5 billion lb.

The result then is a respectable capacity use rate for *p*-xylene in this year of renewed recession. If capacity in actual use most of the year is 5.0 billion lb, possibly 4.9 billion lb, and production is 3.8 billion lb, the operating rate then becomes a much healthier 76%, highest among the five leading basic petrochemicals.

In 1982, the operating rate is expected to hold to at least 75% because Hercor isn't expected to run very much. Demand, too, might pick up by 100 million lb or so as use in polyester bottle resins continues to grow relatively rapidly. If the second half of 1982 is an improving economic period, then production for 1982 might hit 4 billion lb again. That kind of outlook likely will help keep prices up after the current business recession.

Another factor that could strengthen *p*-xylene is a possible output ceiling forced by a crimp in supply of its feedstock, mixed xylenes. Mixed xylenes come mainly from oil refineries but also from olefins plant coproducts. Weak gasoline demand means less severe operation of refineries' catalytic reforming units, reducing slightly the xylenes supply from this source. Poor ethylene fortunes, spurring use of light hydrocarbon feedstocks in olefins plants, have reduced production of pyrolysis gasoline, the aromatics-rich byproduct stream. The result has been a lessening of mixed xylene supplies from this source.

As yet, feedstock constraints have not developed for *p*-xylene producers. But if this happens, the operating rate would have to drop. Producers then might get some price increases, which could more than offset unavoidably high capital charges per pound of product at low capacity-use levels.

Outside the bottle market for polyester, only small market increases are expected in 1982. Polyester film demand, roughly 10% of the total, will grow slightly, but not enough to do much for *p*-xylene. The rest of the U.S. market will depend on demand for polyester fibers, which is expected to move up.

xylenol feeds. The recycle is correspondingly rich in cresols. The addition of steam also improves the phenol yield another 4%. The net phenol yield can be as much as 57% from mixed cresol/xylenols.

Commercial development of the Dynaphen process has been limited to preliminary economic evaluations. The assumptions have been mainly that the process would be used with coal liquefaction plants and the analysis suggests that phenol recovery in a Dynaphen plant would increase total product value about 8.3%.

The economics of a stand-alone Dynaphen plant are highly dependent on feed composition. If the feedstock is cheap, as would be the case for by-product lignin from a pulping operation or for coal gasification process water, a stand-alone plant probably would be as profitable as it would be if it were an incremental investment for a large coal liquefaction plant. In any case, the Dynaphen plant is an adjunct to a primary chemicals producer rather than a primary process itself.

Joseph Haggin, Chicago

West Germany pursues active coal conversion development program

The West German dilemma with rapidly escalating oil prices is about the same as that of most other countries, except that it may be more intense. Like the U.S., West Germany has considerable coal reserves, about the only realistic long-term energy source available with the exception of nuclear power. Thus West Germany has an active coal conversion development program. The scope and current status of that program were outlined at the recent meeting of the American Institute of Chemical Engineers in New Orleans by Rudolf Specks and Arno Klusmann of Ruhrkohle Oil & Gas.

Specks and Klusmann estimate West German coal reserves to be sufficient for several hundred years at projected rates of consumption. There is also considerable industrial experience with large-scale coal conversion processes.

This experience has been used to advantage in a national program for coal conversion that is now in the demonstration-plant stage. It is not believed that any commercial plants will appear before the mid-1980's.

Coal conversion program has these projects finished or nearing completion . . .

Operator	Ruhrkohle A.G. Ruhrgas A.G. STEAG A.G.	PCV (Flick) Sophia Jocoba	Ruhrkohle A.G. Ruhrchemie A.G.	Deutsche Shell A.G.	Saarbergwerke A.G. Dr. C. Otto & Co.
Coal feed rate	7 tons/hour	1.5 tons/hour	6 tons/hour	6 tons/hour	10 tons/hour
Products	Syngas; SNG	Syngas	Syngas	Syngas	Syngas; SNG
Process	Modified Lurgi pressure gasification	Fixed bed	Modified Texaco pressurized coal dust gasifier	Shell-Koppers dust gasifier	Saarberg/Otto gasifier
Cost	$70 million	$11 million	$21 million	$44 million	$31 million
Schedule	Construction by 1979, tests through 1983	Construction by 1979, tests thereafter	Construction by 1978, tests thereafter	Construction by 1978, tests thereafter	Construction by 1978, tests thereafter

. . . in progress . . .

Operator	Ruhrkohle A.G. Veba Oel A.G.	Saarbergwerke A.G.	Gulf Mitsui Ruhrkohle A.G.	Exxon, DOE Electric Power Research Institute Kentucky Japanese consortium Phillips, Arco Ruhrkohle	DOE, Kentucky Ashland Oil Standard Oil (Ind.) Mobil, Conoco Ruhrkohle A.G. Veba Oel A.G.
Coal feed rate	200 tons/day	6 tons/day	30 tons/day	200 tons/day	160–480 tons/day
Process	Catalytic hard coal liquefaction	Catalytic hard coal liquefaction	SRC-II	EDS (Exxon)	H-Coal Process
Products	Gas Raw naphtha Middle distillate	Gas Raw naphtha Middle distillate	Gas Raw naphtha Middle distillate	Gas Raw naphtha Middle distillate	Gas; raw naphtha Middle distillate Heavy oil
Schedule	Operation begins in 1981	Operations begin in 1980	Operations began in 1978	Operations began in 1980	Operations began in 1980
Cost	$185 million	$13 million	$19 million	$150 million	$132 million
Location	West Germany	West Germany	Tacoma, Wash.	Baytown, Tex.	Catlettsburg, Ky.

. . . and being planned

Operator	Ruhrkohle A.G. Ruhrgas A.G.	Ruhrkohle A.G. Ruhrchemie A.G.	Deutsche Shell A.G.	Deutsche Texaco A.G.	PCV (Flick)	Saarbergwerke A.G.	Kerf	VEW
Coal feed rate	3 million tons/year	400,000 tons/year	300,000 tons/year	400,000 tons/year	500,000 tons/year	400,000 tons/year	100,000 tons/year	1.8 million tons/year
Process	Lurgi pressure gasifier	Texaco pressure gasifier	Shell Koppers	Texaco pressure gasifier	Fixed-bed gasifier	Saarberg/Otto	Saarberg/Otto	Partial gasification with air
Products	SNG Town gas Syngas	Syngas	Syngas	Syngas	Syngas for conversion to SNG	Syngas for combined power plant	Reducing gas	Fuel gas for combined power plant
Operation	1984	1985	1985	1985	1985	1985	1985	1985

Phillips has your Sulfur Chemical

Mercaptans
Ethyl mercaptan
n-Propyl mercaptan
iso-Propyl mercaptan
n-Butyl mercaptan
sec-Butyl mercaptan
iso-Butyl mercaptan
tert-Butyl mercaptan
n-Hexyl mercaptan
Cyclohexyl mercaptan
n-Octyl mercaptan
tert-Octyl mercaptan
tert-Nonyl mercaptan
n-Dodecyl mercaptan
tert-Dodecyl mercaptan
tert-Tetradecyl mercaptan
tert-Hexadecyl mercaptan
tert-Mixed mercaptans
(C_9, C_{12})
(C_{12}, C_{14}, C_{16})
2-Mercaptoethanol
Benzyl mercaptan

Sulfides
Ethylthioethanol
Di-n-butyl sulfide
Di-tert-butyl sulfide
Ethylthioacetate
Phenylthioethanol

Disulfides
Di-tert-butyl disulfide
Di-tert-dodecyl disulfide
Di-n-butyl disulfide

Polysulfides
Di-tert-butyl polysulfide

Sulfones
Sulfolane (anhydrous)
Sulfolane-W
Sulfolene

New Developmental Sulfur Chemicals From Phillips:

We can now produce developmental to commercial quantities of Di-n-propyl and Di-sec-butyl disulfides, Ethanedithiol, Thiodiglycol and Di-tert-nonylpolysulfide.

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Even then, the products are not expected to be really competitive with products from imported oil. However, despite the necessarily slow pace of development, alternative sources to imported oil for energy and chemicals are considered of enough importance to warrant national support. At the same time, the Ruhrkohle spokesmen note, the program must be simple and market-oriented.

As of now, about $450 million has been made available by the West German government for coal conversion technology development. Most of this money has gone into pilot plant construction and subsequent tests. The pilot plants have been divided roughly equally between coal gasification and liquefaction. The former have been primarily domestic but the latter have involved much international cooperation, particularly with the U.S.

About 35 processes have been developed in West Germany for gasification but only three have been commercialized. All the development effort since the 1973 Arab oil embargo has been based on these three processes as starting points.

The Lurgi fixed-bed gasifier has been in use the longest and is suited particularly for the production of town gas and substitute natural gas (SNG). This process may be used at elevated pressures, and the products may contain up to 10% methane. The Koppers-Totzek process is characterized by an entrained bed and can be operated at temperatures up to 2000 °C. There are no by-products, and the methane content is very small. The K-T process is considered particularly suitable for synthesis gas production in support of petrochemicals production. The Winkler fluid-bed gasifier is useful in processing lignite and other low-grade coals.

Five gasification pilot plants are now in operation or have been closed down following project completion. Although the official completion date isn't until sometime in the mid-1980's, the current claim is that all have been successful. There isn't much doubt about the success since they all involve established technology.

The principal purpose of the pilots appears to have been acquisition of design data for demonstration plants that are now in the planning and/or construction stage. In all of the gasification pilot plants, the principal product was synthesis gas. Two of them also produced SNG.

West German coal liquefaction development is based on extensions of the old Bergiua/Pier process, and on newer processes being developed jointly with U.S. participation. Five major liquefaction projects are under way and are scheduled to be completed by 1983. The foreign participants include the U.S. Department of Energy, U.S. private companies, the state of Kentucky, and some Japanese interests.

In addition to the projects completed or still under way, eight new proposals are now under consideration, six of them aimed at synthesis gas production. The production from envisioned commercial versions of the processes would be typically that from a feed rate of 600,000 tons per year of hard coal, and throughput would be matched to the needs of large fuels and chemical complexes.

The biggest single project is claimed by Ruhrkohle/Ruhrgas to be capable of processing 3 million tons per year of hard coal and would cost about $1.3 billion. A Ruhr industrial complex would be developed in stages and would provide gases for a public network as well as synthesis gas and SNG for industry.

The second biggest project is planned by Saarbergwerke to provide the Saar region with 800,000 tons per year of gasoline from coal. It is scheduled to be commissioned by 1987. The very high costs of the plants under consideration will require government participation and the formation of industrial consortia for the necessary capital. □

Coal-based chemicals competitive in 1980's

A dominant theme at the American Institute of Chemical Engineers meeting in New Orleans was the advent of coal-based petrochemical plants. According to Arthur S. Nislick, a vice president of C-E Lummus, it is quite likely that coal conversion can become competitive for production of petrochemicals in the 1980's.

This competitiveness is considered probable despite the current oil glut and the threat of price manipulation of crude supplies by the Organization of Petroleum Exporting Countries. Political instability, particularly in the Middle East, and the economic stress originating in high oil prices have conspired to give coal some advantages that this energy source otherwise might not have enjoyed for some time.

The new trend toward coal-based plants already has been established